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TURBINE BLADE
DATA ACQUISITION SYSTEM
USER'S GUIDE

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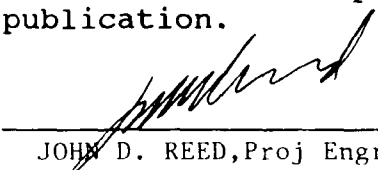
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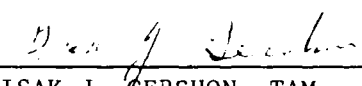
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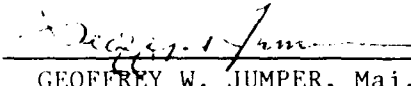
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This report provides design and technical documentation on the Turbine Blade Data Acquisition System developed by the Electronic and Computer Development Laboratory, within the University of Dayton Research Institute. It was designed and fabricated as an analytical tool for structural testing and research on turbine components as part of the Noncontacting Stress Measurement System. This research effort was performed for the Aerospace Mechanics Group of the Research Institute. Michael Drake was the Principal Investigator and Robert Dominic was the Research Engineer in charge of daily activities for this project.

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1. GENERAL DESCRIPTION

The Turbine Blade Data Acquisition System (TBDAS) is a microprocessor-based system for obtaining information on the vibration modes of the blades on a rotating turbine. The system uses optical detectors to obtain data on blade arrival time with respect to a one-pulse-per-revolution detector. Up to four detectors may be connected to the system. In addition to recording blade arrival data, the system can generate a histogram for a particular station. The system can also generate a real time display of blade arrival times for up to five blades at a particular station.

The TBDAS electronics consists of five major components, the 1PPR detector, the 1PPR amplifier, the detector/electronics chassis, the computer system rack, and the video graphics terminal. Additionally, a printer may be attached to the system for obtaining hardcopy outputs of the terminal screen. These components are shown in the block diagram of Fig. 1.

The 1PPR detector, together with the 1PPR amplifier, provide a TTL compatible signal to synchronize the system. In addition, up to four fiber-optic cables may be connected to the system.

The detector/electronics chassis receives the signals from the fiber-optics and the 1PPR, converts these signals to time data, and provides this time data to the computer system. A 10 MHz counter in the detector/electronics chassis drives five latch cards, one for the 1PPR and one for each station connected to the system. When the system receives a 1PPR pulse, the value of the counter is latched into the 1PPR latch card, and then the counter is reset. When a blade passes a station, a pulse is generated which causes the value of the counter to be latched into the card corresponding to that station. When a value is latched into a card, the card sends a valid data signal to the computer, which then reads the data and resets the card. Thus, all data is referenced in time to the 1PPR, and data concerning blade arrival time may be extracted from the data. Fig. 1a shows the layout of the chassis.

A 9-track tape unit is provided to allow the data to be stored for later reference. The system is a write-only system, so data must be read and analyzed on another computer.

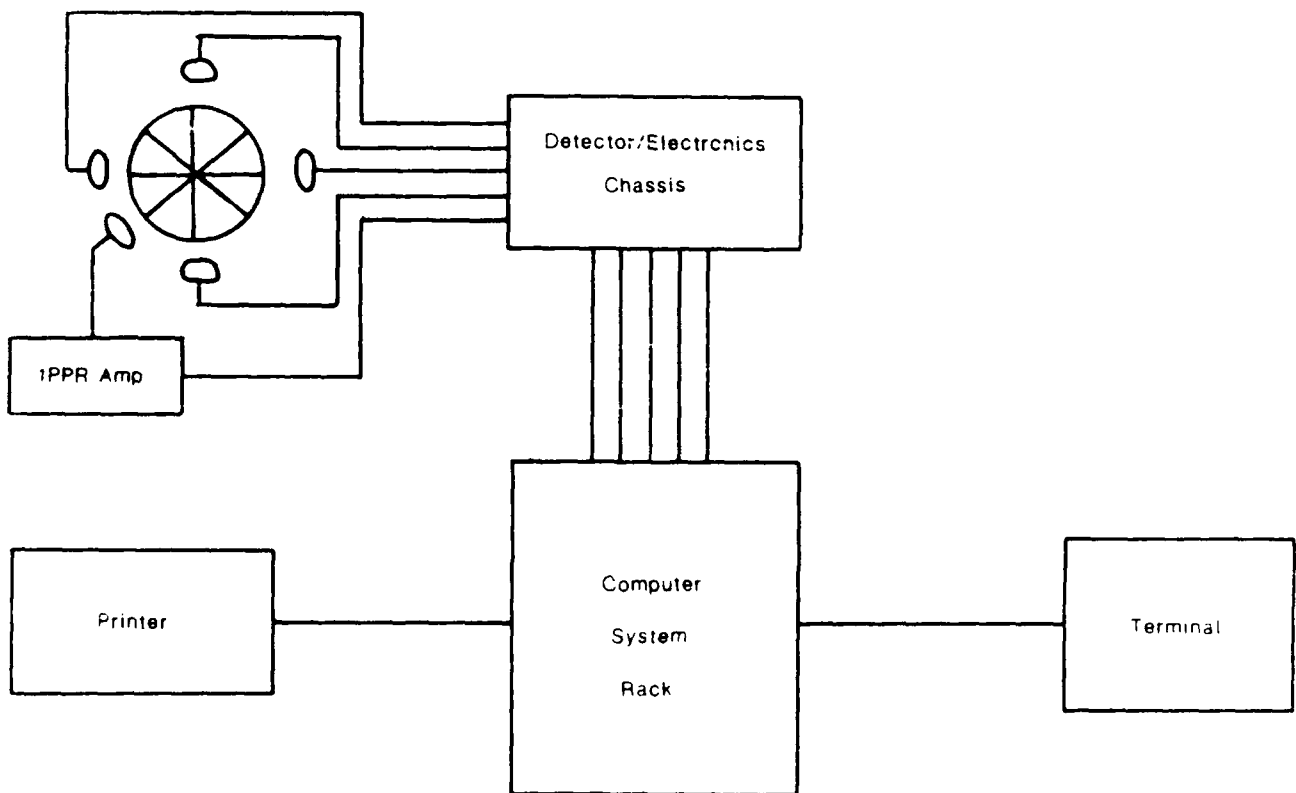


Figure 1. Turbine Blade DAS Block Diagram

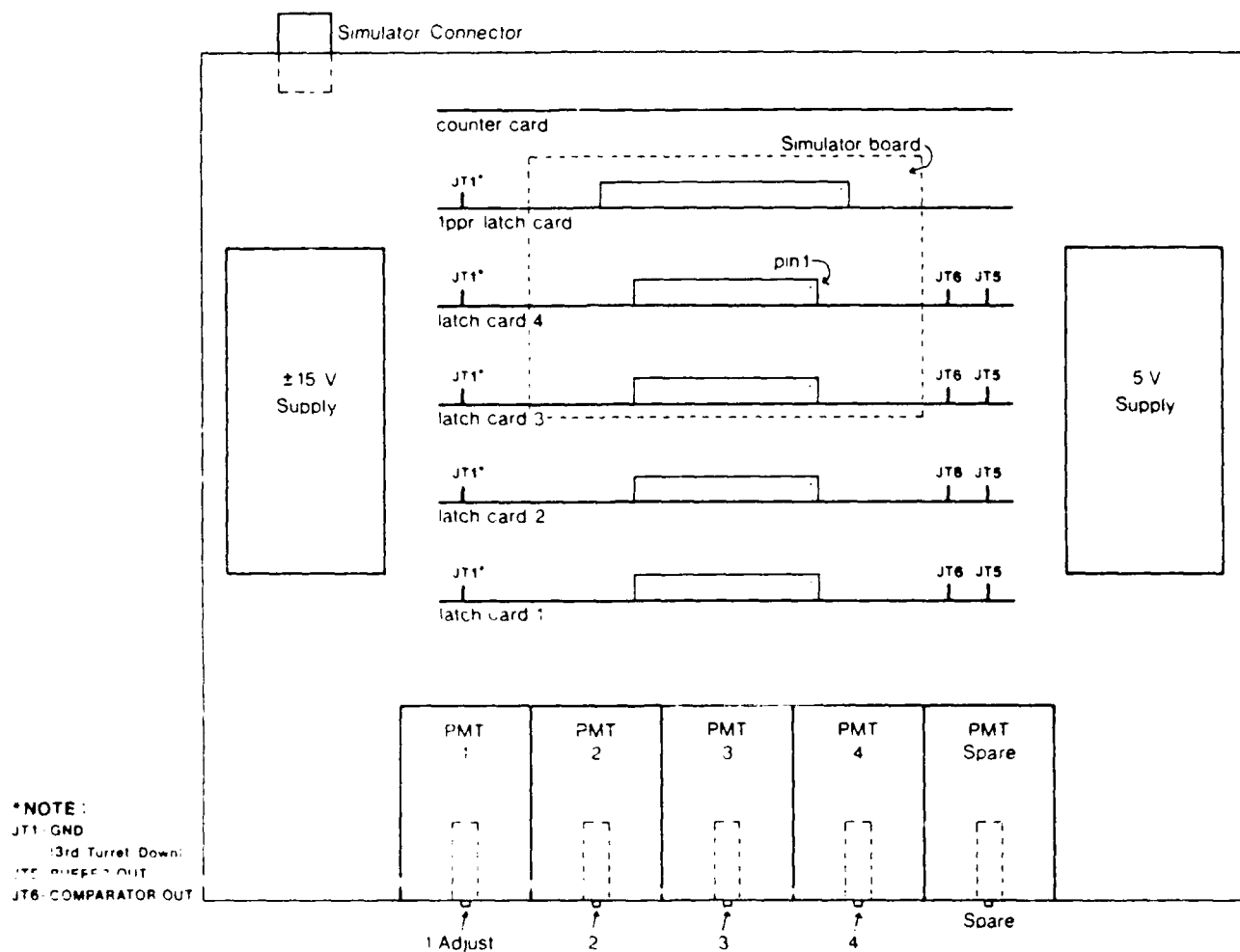


Figure 1a. Detector/Electronics Chassis Layout

2. OPERATING PROCEDURES

This section provides a detailed description of the steps in the operating checklist which follows. You should read through this section to familiarize yourself with the system.

(1) Turn on power switches.

The TBDAS has five components which are required to be powered up for operation. These are the Tektronix terminal, the main system rack, the detector electronics chassis, the 1PPR amplifier, and the 1PPR photo-detector. The detector electronics chassis MUST be powered up at least one-half hour before running a valid test to allow the PMT power supplies to stabilize.

(2) Load tape unit

If data will be stored during this session, the magnetic tape unit must be loaded and placed on line. Open the door on the unit and place a blank tape on the bottom spindle. To load the tape, thread the tape through the head assembly as shown in the diagram on the upper right corner of the tape unit. After threading the tape onto the takeup reel, press the "load" button on the tape unit control panel. The tape will advance to the tape mark. Now press the "reset" button, followed by the "1600" button. Finally, press the "online" button. The tape is now ready for a "WRITE DATA" command.

(3) Check system date and enter new date if necessary.

The computer will print out the system date on the terminal and ask you if you would like to change the date. If the date shown is correct, type an "N" and press the RETURN key. If the date is incorrect, type a "Y" and press the RETURN key. The system will then prompt you for the year. Enter the last two digits of the year and press the RETURN key. Then enter the month, followed by RETURN, and day followed by RETURN.

(4) Check system time and enter new time if necessary.

The computer will print out the system time on the terminal and ask you if you would like to change the time. To accept the time shown, type an "N" followed by a RETURN. To change the time, type a "Y" and a RETURN. The computer will prompt you for the hour. Enter the current hour and hit RETURN. The computer will then prompt you for the minutes. Enter the correct minutes and press RETURN.

(5) Enter number of stations (1 to 4).

The computer will prompt you for the number of stations you wish to take data on. This number may be from one to four, but the stations sampled will always start with one; (i.e., if you select 2, stations one and two will be sampled).

(6) Enter specimen I.D.

The computer will prompt you for a specimen I.D. This entry may consist of a string of characters up to 16 characters in length. If you enter more than 16 characters, the computer will prompt you to reenter the I.D. The entry is ended by pressing the RETURN key. A line of underscores shows the maximum length of the I.D. on the screen.

(7) Enter specimen description.

After entering the I.D., the computer will prompt you for a specimen description. This description is entered as a string of characters up to 80 characters long, and is also ended with a RETURN. Two lines of description maybe entered, but each line must be ended by a RETURN. A line of underscores will show the maximum length of each line.

(8) Enter specimen radius.

The computer will prompt you for the specimen radius. This may be any character string up to 16 characters in length, followed by a RETURN. Since the data is entered as a string, no units are associated with the variable. The data may be entered in any units (i.e., inches, millimeters, etc.). A line of underscores indicates the maximum length of the value.

(9) Enter number of blades.

The computer will prompt you for the number of blades on the turbine. The system is capable of handling turbines with up to 70 blades.

(10) Select operation to be performed.

The computer will prompt you to enter the operation to be performed. The options which may be selected are the following:

- C = Change Date / Time / Specimen Data
- D = Discard Data
- H = Histogram
- R = Real Time Display
- S = Start Taking Data
- W = Write Data To Tape

C = Change Date / Time / Specimen Data

This option allows you to enter new data for the specimen being tested, as well as resetting the system date and time. Selecting "C" will effectively return you to step 2 of this procedure.

D = Discard Data

After you have taken data, the computer will not let you perform any operation except for writing to the tape. This prevents data from a test from being overwritten. Occasionally you may not wish to write the data to the tape. The "D" function discards the data and allows you to proceed with further operations without writing the tape.

H = Histogram

When you select Histogram, the computer will prompt you for the station number you wish to perform the histogram on. Enter the station number and press RETURN. The computer will then prompt you for the number of revolutions used to generate the histogram. Enter the number and press RETURN. If the histogram is being run while data is not being taken, you will be prompted for a histogram I.D. and excitation frequency. The screen will begin plotting the histogram, with a vertical bar representing each blade on the turbine. Hitting the space bar will rescale the maximum value on the display to the value of the next point read. Pressing the RETURN key will return you to the main menu.

R = Real Time Display

When you select the real time display option, the computer will ask for the number of blades you wish to display. You may display from one to five blades. After you have entered the number of blades, the computer will ask you to assign blades to plots on the screen. When the computer prompts you with a

position, enter the blade you wish to have displayed in that position. When all the positions have been filled, the computer will display a real time display of the data for the blades selected. If no data is being taken, the computer will prompt you for a real time display I.D. and the excitation frequency. Hitting the space bar will rescale the maximum value on the display to the value of the next point read. Pressing the RETURN key will return you to the main menu.

S = Start Taking Data

Selecting the "S" option from the main menu begins the process of taking data. The computer will prompt you for the number of revolutions of the turbine you wish to take data on. The number of revolutions is limited by the number of blades. The computer will calculate and print the maximum number of revolutions based on the number of blades entered for the turbine in use. You may enter any number up to this maximum. The system will then prompt you for a run I.D. This may be a string up to 16 characters in length. A line of underscores shows the maximum length. The computer will then ask for a run description. This description is one line up to 80 characters in length. Again, underscores show the length. Next, you must enter the excitation frequency. This may be up to five characters in length. When the excitation frequency is entered, the test will automatically begin. During the test, you may execute histograms and real time displays. When the test is complete, the computer will return you to the main menu.

W = Write To Tape

The write-to-tape option writes the data from the most recent run to the 9-track tape. In addition, a header containing the descriptions and parameters of the test is written.

(11) Turn Off System Power

After all test runs have been completed, turn off the system power.

Operating Checklist

_____ (1) Turn on power switches

- (a) Tektronix Terminal
- (b) Main Rack
- (c) Detector/Electronics Chassis
- (d) 1PPR Detector Amplifier
- (e) Photodiode Detector

WARM UP 30 MINUTES

WARM UP 30 MINUTES

WARM UP 30 MINUTES

WARM UP 30 MINUTES

WARM UP 30 MINUTES

WARM UP 30 MINUTES

_____ (2) If data will be stored during session, load tape.

_____ (3) Check system date and enter new date if necessary

_____ (4) Check system time and enter new time if necessary

_____ (5) Enter number of stations (1 to 4)

_____ (6) Enter specimen I.D.

_____ (7) Enter specimen description

_____ (8) Enter specimen radius

_____ (9) Enter number of blades

_____ (10) Select operation to be performed

C = Change Date / Time / Specimen Data

D = Discard Data

H = Histogram

R = Real Time Display

S = Start Taking Data

W = Write Data To Tape

_____ (11) After test has been performed and data has been written to tape, turn off system power

3. SAMPLE SESSION

This section illustrates a sample session using the TBDAS. We are using the simulator to generate the signals for this session. The simulator generates data for a turbine with five blades running at 625 RPM. We will assume a radius of 8 inches. We will also assume that we are running a test on October 1, 1987 at 9:00 a.m.

(1) Turn on the power for the system. Turn on the power for the monitor first. Next, power up the 1PPR detector, the 1PPR amp and the detector electronics chassis. Then turn on the computer rack. At this point, the computer should be prompting about the date.

(2) We will be taking and recording data during this session, so we need to load the tape unit. Open the door on the unit and mount a tape on the lower spindle. Now thread the tape as shown in the diagram on the upper right corner of the unit. When you have the tape threaded and engaged on the take-up reel, press the "load" button on the keypad on the upper left corner of the unit. The tape will advance to the timing mark. Now press the "reset" key, the "1600" key and the "online" key in order. The tape drive is now ready to record information.

(3) Lets assume the system date is not the correct date. Type in a "Y" to change the date. The system will prompt you to enter the year. Type "87" and press the RETURN key. Next we enter the month, "Oct" and RETURN. Finally, the day, "1" and RETURN.

(4) Now the system will inquire about the system time. Let's set the time also. Type a "Y" followed by RETURN. Now well enter the hour, "9" and return. Next the minutes, "00", and RETURN.

(5) Now we need to enter the number of stations. We can run up to four stations, and the simulator is set up for four, so enter a "4" and RETURN.

(6) The computer should now be prompting us for a specimen I.D. Let's call our specimen TB805-625. Enter "TB805-625" and RETURN.

(7) Next we need to enter a specimen description. The computer shows us what the first line of the current description is (it should be blank), and a line of underscores to designate the maximum length. Enter "This is a sample session" followed by RETURN. The computer now shows us the current second line (also blank right now). Enter "This session uses the simulator to generate the input signals" followed by RETURN.

(8) The computer then asks for the specimen radius. Since we assumed it would be 8 inches, enter "8" and RETURN.

(9) Now we need to enter the number of blades. The simulator generates a signal with five blades, so type "5" and RETURN.

(10) The computer will now clear the screen and print the main menu. (see Fig. 2) The screen tells us we have the following options:

- C = Change Date / Time / Specimen Data
- D = Discard Data
- H = Histogram
- R = Real Time Display
- S = Start Taking Data
- W = Write Data To Tape

Let's try some of the options. The C option will take us back to the beginning of the program and allow us to modify any of the data we entered in steps 2 through 8. Press "C". This takes you back to the date prompt. Since the date and time are already set, press "N" in response to the date and time inquiries. The next prompt is for number of stations, and it shows a current value of "4", which is what we entered the last time through these prompts. In fact, all of the current responses will be those we entered before. You can accept these values by pressing RETURN. Accept all the current responses until you are back at the main menu.

We'll skip the D option for now. Instead let's generate a histogram. Press "H". The computer will ask us for the station we wish to perform the histogram on. Let's look at station 2. Press "2" and RETURN. The computer will prompt us for the number of revolutions we wish to perform each histogram over. Enter "10" and RETURN. Next we need to enter a histogram I.D. Enter "Sample" and RETURN. The histogram should now appear on the screen (see Fig. 3) and update itself continually. Pressing RETURN takes us back to the main menu.

Now we'll generate a real time display. Enter "R". Again the system will ask us which station we wish to display. We'll look at station 3 this time. Enter "3" and RETURN. Now it asks how many blades we want to look at. We can display from one to five blades. Lets look at three of them, blades 1, 3, and 5. Enter "3" and RETURN. The computer now asks for plot assignments. The plots are numbered from the top of the screen to the bottom. For plot 1, enter "3" and RETURN, plot 2, "5" and RETURN, and plot 3, "1" and RETURN. Next we need to enter a real time plot I.D. Type "Sample RT" and RETURN. Next, enter the excitation frequency as "625" and RETURN. Now the real time display will appear as in Fig. 4. Again, RETURN takes us back to the main menu.

NSMS Data Acquisition System

C = Change Date / Time / Specimen Data

D = Discard Data

H = Histogram

R = Real Time Display

S = Start Taking Data

W = Write Data To Tape

Figure 2. Main Menu Terminal Display

TEST RUN Station-1 625 Hz 625 PPM 13-Oct-57 09:14:40

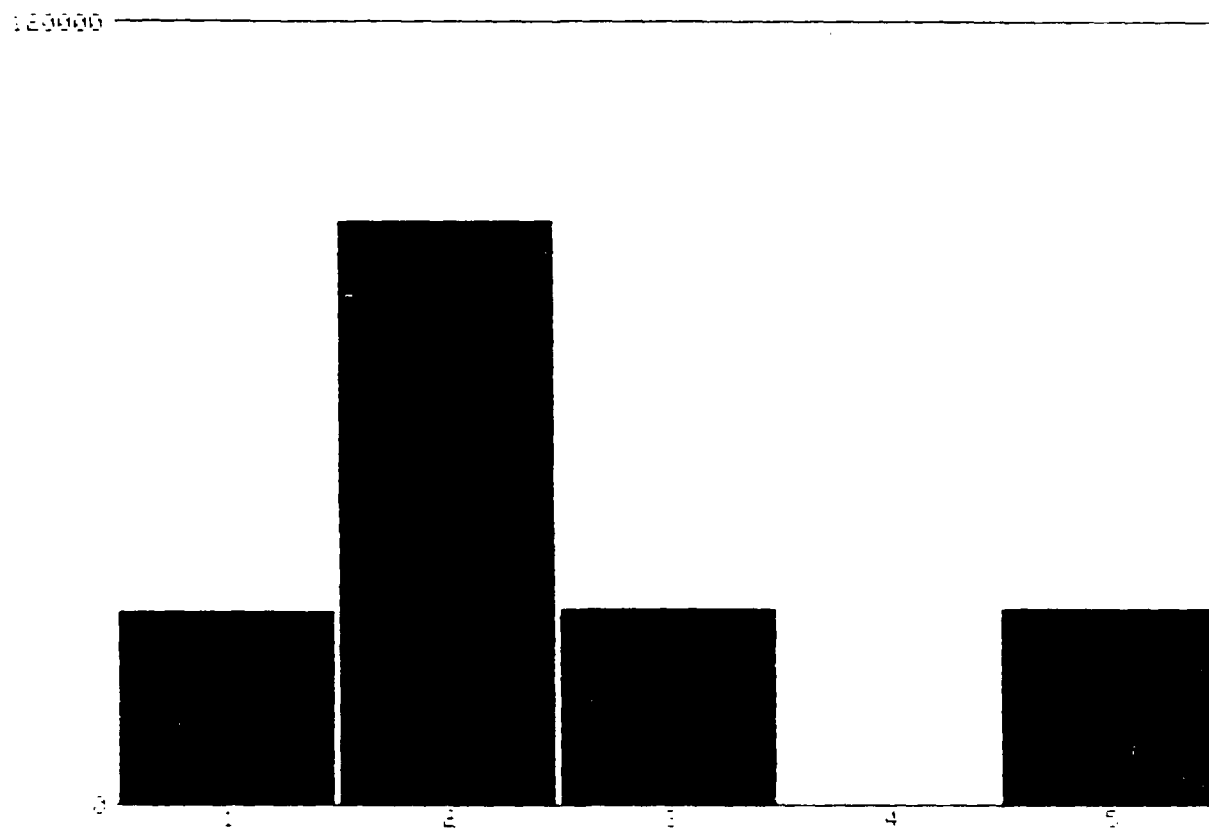


Figure 3. Histogram Terminal Display

TEST RUN Station-1 625 Hz 625 PPM 13-Oct-87 08:36:56

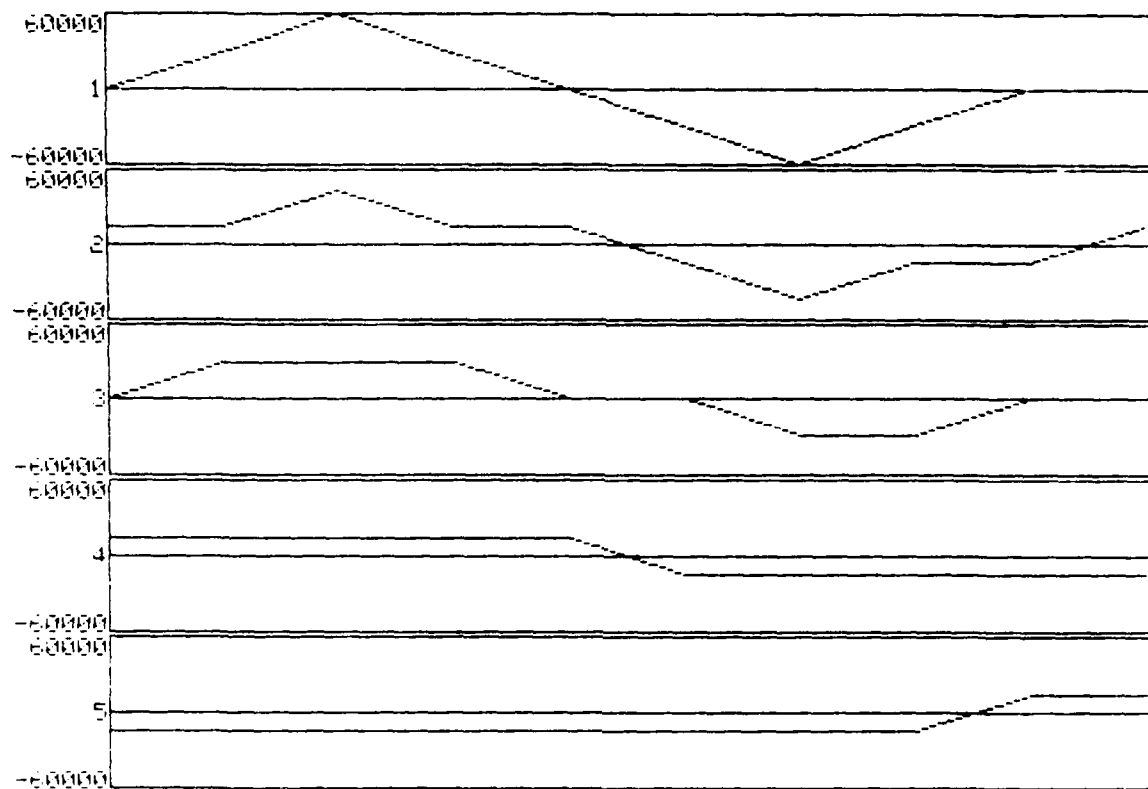


Figure 4. Real Time Terminal Display

We should be back at the main menu again. Let's take some data. Press "S". The system will prompt us for the number of revolutions of the turbine we wish to take data over. Let's take data over 2000 revolutions. Enter "2000" and RETURN. Next we need to enter a run I.D. Enter "Test 1" and RETURN. The computer then asks for a run description. Enter "Sample run using simulator" and RETURN. Next enter "625" and RETURN for the excitation frequency. The main menu will appear with the additions of the maximum, minimum, and current speeds, as well as the number of revolutions of data taken (see Fig. 5). At this point, the histogram and real time display will still function as before, except that I.D.s and excitation frequencies will not be requested. Try running both options. When the test is complete, the computer will return you to the main menu.

Once data for the run has been taken, only the W and D options are active. We'll use the W option now. First, make sure that a tape is loaded in the recorder (see Step 2). When the recorder is set up, press "W". The computer will then write the data to tape and return you to the main menu. If you do not wish to write the data to tape, press "D". This discards the data for the last run and returns you to the main menu. Using the D option during the test will discontinue the test and return you to the main menu. Try running some more tests, experimenting with the D option.

(11) When all tests are complete, unload the tape and turn off the power for all the system components.

NSMS Data Acquisition System

Revolution 204 of 1000

	<u>Current</u>	<u>Minimum</u>	<u>Maximum</u>
Speed :	625	625	625 RPM

C = Change Date / Time / Specimen Data

D = Discard Data

H = Histogram

R = Real Time Display

S = Start Taking Data

W = Write Data To Tape

Figure 5. Main Menu Run Time Terminal Display

4. SYSTEM CONNECTIONS

The following is a description of the system connections required for operation of the TBDAS:

Fiber Optics: Connections for up to four fiber-optic cables are provided. The cables connect to the system on the front panel of the detector/electronics chassis. The fifth connection is for a spare PMT in the event one of the first four channels becomes defective. (The chassis must be rewired to allow the use of this spare PMT). If less than four cables are connected, they must be connected in ascending order from channel one to four. Any unused connections should be sealed to prevent light from entering the chassis.

1PPR: The 1PPR detector is connected to the 1PPR amplifier through the photodetector input connector on the front panel. The TTL output is then connected to the BNC connector on the rear panel of the detector/electronics chassis.

Data Cables: The five data cables are the ribbon cables extending from the rear of the detector/electronics chassis. These are connected to the ribbon connectors on the rear panel of the computer system rack. The cables are labeled to show which connector they should be plugged into.

Terminal: The cable from the Tektronix terminal is connected to the Terminal port on the rear panel of the computer system rack.

Host: The host connector on the rear of the computer system rack is for programming use only. No connections are required for operation.

5. SIMULATOR

A turbine blade simulator is included internal to the detector/electronics chassis. The simulator is used to check for proper functioning of the TBDAS electronics. The simulator drives five LEDs which simulate the fiber-optic connections to the unit. The LED cable is connected to the MS connector on the rear of the detector/electronics chassis. The LEDs are labeled 1,2,3,4 and 1PPR to designate where they plug into the system.

The simulator generates signals which simulate a five blade turbine rotating at 625 r/min. The speed is constant, but the blades have a simulated dither in which each blade may vary by up to ± 6 ms.

6. SYSTEM ADJUSTMENTS

The TBDAS requires three adjustments to assure proper operation. These are described here:

PMT Output: The output of the PMT should be adjusted to provide maximum amplitude while still maintaining a clean waveform. The adjustment for each channel is provided on the front panel of the detector/electronics chassis under the fiber-optic inputs. The signal may be monitored using an oscilloscope connected to the buffer test point shown in Fig. 1a for each channel. Fig. 6 shows the approximate waveform which should be expected.

PMT Comparator Threshold: The comparator should be set to provide accurate and reliable triggering on the PMT pulse. The adjustment for the comparator is found on the solder side of each PMT latch card. The signal may be monitored using the comparator test point shown in Fig. 1a. Fig. 6 shows a PMT waveform with the comparator waveform. Fig. 7 shows a series of pulses, verifying reliable triggering.

1PPR Comparator Threshold: Again, the comparator should be set to provide accurate and reliable triggering on the 1PPR waveform from the amplifier. The input and output test points are shown in Fig. 9. The waveforms which should be expected are shown in Fig. 8.

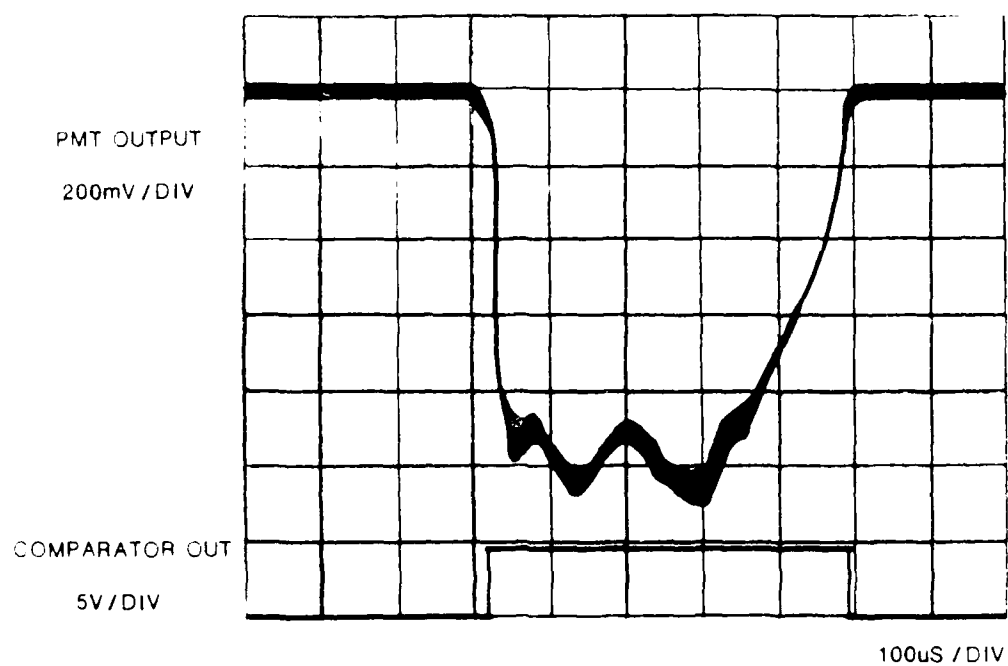


Figure 6. PMT / Comparator Outputs

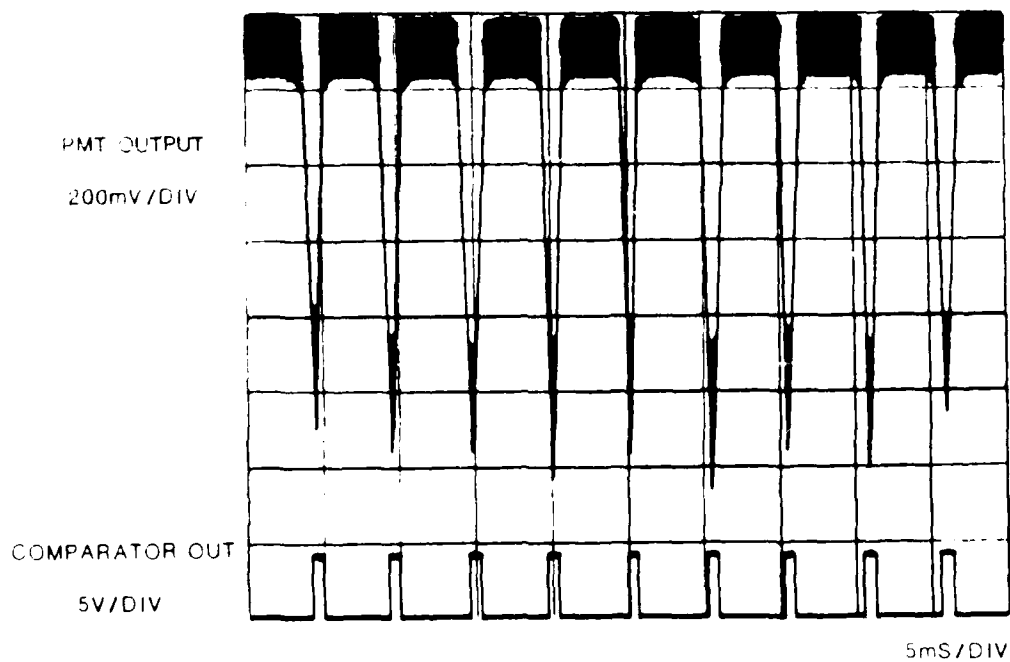


Figure 7. PMT / Comparator Output Pulse Train

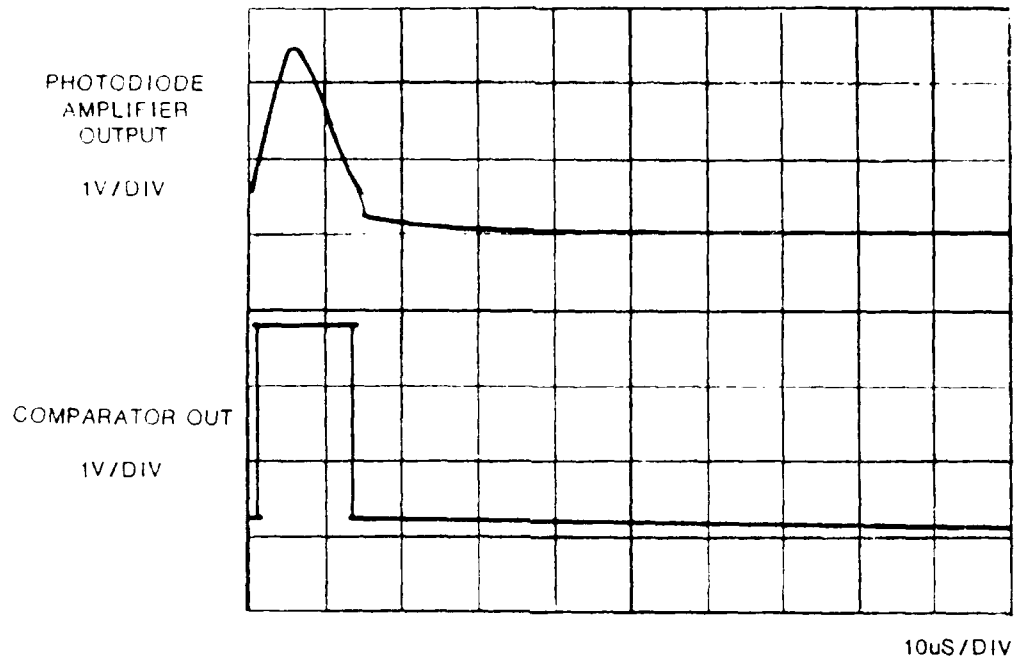


Figure 8. 1PPR Waveforms

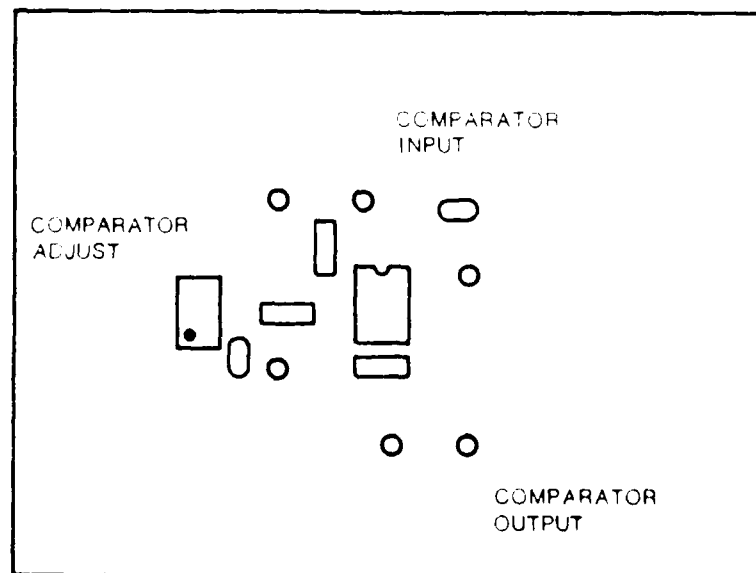


Figure 9. 1PPR Comparator Layout